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INDIGO MANUFACTURE IN
MADRAS



Department of Agriculture, Madras.

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INDIGO MANUFACTURE IN MADRAS.

INTRODUCTION.

WITH the demand for dye stuff which became universal when the supplies of synthetic dyes from Germany were cut off those natural dyes which were still obtainable found a ready market. The most important of these of course was indigo and although the extent to which it was cultivated had seriously decreased in the last two decades it was still a remunerative crop in many districts and under the advice of officers of the Madras Agricultural Department ryots placed a great deal more land under indigo than they had done for years past. The normal area under indigo in the Madras Presidency was until a few years ago some 110,000 acres but had decreased to some 80,000 ; in fact in 1913-14 it was as low as 55,000 acres but in 1914-15 there was a return to 71,683 and the effect of the high prices then ruling was seen in the following years when in 1915-16, 222,000 acres were sown and in 1916-17, 460,000 acres.

Cultivation was also extended in other Provinces and very early on the demand arose that if possible the industry should be placed on such a footing that it would be able to hold its own against the synthetic product even after the war and in February 1915 the Government of India held an informal conference at Delhi to consider questions connected with the production of the natural dye. Questions of agriculture, manufacture and marketing were discussed and it was recommended that a Chemist should be engaged to make investigations upon possible improvements in manufacture and standardization of the product, and the desirability of marketing the natural indigo in forms suitable to the requirements of users was emphasised. As a result of this conference Mr. W. A. Davis, B.Sc., was appointed and since his arrival in India in May 1916 has been working at Pusa upon the problems indicated.

The matter was also taken up at Home and an Indigo Committee was formed in London and has been advising upon the questions of marketing and competition with the synthetic product. It suggested a selling organization in England and members of the Behar Planters' Association have subscribed a sum of money to thoroughly test the possibility of standardizing and supplying natural indigo in various forms (cakes, paste, powder, etc.) and an agent has been appointed to push the business.

In G.O. Mis. No. 923, Revenue, dated 28th March 1917, the Madras Government accepted the suggestion of the Director of Agriculture, Madras, that, working in collaboration with Mr. Davis, I should undertake in this Presidency the investigation of the methods of manufacture followed by the ryots with the object of suggesting improvements in these methods, of enquiring into and, if possible, reducing adulteration and generally report upon existing conditions.

The indigo season in Behar commencing rather earlier than is general in Madras I was enabled to visit with Mr. Davis some of the large European-managed factories in the neighbourhood of Pusa and thus make myself acquainted with the conditions under which indigo is manufactured under the best modern conditions. Upon my return I toured in the different indigo growing districts of the Presidency, arranging my tours so that, as far as possible, I should be on the spot when actual manufacture was in progress. Growers, vat-owners and merchants were spoken with and samples of indigo were taken from the different districts for analysis.

Regarding the history of indigo growing in Madras there is little record, but that it dates from very early times is evident from the reference to it in the Travels of Marco Polo at the end of the 13th century. He also refers to it as seen in Guzerat and it appears that West India, in Bombay, was the chief centre of the industry. It was not until the eighteenth century however that it was freely imported into Europe, and became an important article of commerce when the East India Company took an interest in it. The trade became so valuable that the growing was taken up widely in the tropical colonies and especially in the West Indies where the manufacture flourished until sugarcane and other crops were found to be much more profitable and displaced it. The reputation of Indian indigo had suffered even then in consequence of the excessive adulteration practised by the Indian manufacturers in whose hands the trade lay and the East India Company obtained the services of European planters from those other colonies and persuaded them to settle in Behar and Bengal, and it is from this time that the superiority of the indigo produced in these provinces dates. The manufacture spread into the adjacent districts and the production from the western side gradually fell away.

Indigo in Madras.—Next to Bengal, Madras became the most important indigo-producing province and exports were often more than 50,000 cwts. per annum, with a value of over a crore of rupees. Recently the chief markets for Madras indigo have been in Egypt and Japan and only very superior qualities were exported to Europe.

The chief indigo-growing districts in Madras were South Arcot, Cuddapah, Nellore, Guntur, Kurnool, with appreciable quantities in Chingleput, Kistna, Chittoor and Vizagapatam. Throughout the Presidency the cultivation and manufacture is entirely in the hands of Indians with the exception of Vizagapatam where Messrs. Ripley & Co. supply seed to the ryots and control the manufacture. The produce from their factories does not come upon the markets here but being of high average quality is shipped direct to England. The chief indigo markets are in Prodattur in the Cuddapah district and in Madras, and it appears that the produce from Nellore and the districts surrounding Madras is the best produced here, being of good average quality and free from adulteration. The Lankas of the Godavari yield



POT' MANUFACTURE. VIZAGAPATAM.

a medium quality indigo whilst that from the Ceded districts is very variable, some being exceedingly good whilst some is of the lowest quality possible.

South of Madras the produce is in general not equal to that from the other districts but this may be due to the large proportion of dry leaf indigo made there, the practice of manufacturing from the dried leaf not being followed outside South Arcot.

In my tours I visited vats in Vizagapatam, Gōdāvari, Guntūr, Cuddapah, Chittoor, Chingleput and South Arcot, to find that the conditions prevailing in the industry here are not comparable with those associated with it in Behar. It is only in Vizagapatam that European firms have any control and there the lands are purely Indian owned, the ryots obtaining seed from Messrs. Ripley & Co. at a fixed rate and sowing only as a catch crop after the rains. Only one crop is possible before August and if the rains, which fall in that district about this time are early even this crop may be sacrificed by the ryots and ploughed in that the land may be prepared for paddy. Messrs. Ripley & Co. own all the vats, which are larger than usual in this Presidency and are built in ranges so that there is a factory production on a scale comparable with that in Behar. Weavers here and there however have imitated the arrangements by having lines of earthen pots of 70 or 80 gallons capacity in which the leaf is steeped and the liquor beaten. No care is exercised by them in the manufacture, the indigo is of poor quality and is made only for their own use, but these pot installations are a source of annoyance to the larger factories as they purchase leaf at higher rates and the factories lose when this leaf has been produced from seed distributed by them.

In the Gōdāvari the vats I saw had been erected by Nellore merchants, ryots growing indigo on their own lands and selling the leaf at agreed-upon rates to the vats. This year owing no doubt to the difficulties of shipping the Nellore people did not appear during the indigo season and the ryots worked the vats and manufactured the indigo themselves.

In all other districts the arrangements for manufacturing are very simple. The vat owner is generally a better class ryot who has some portion of his land under indigo but he will also purchase the leaf crop from his neighbours or hire the vats to them that they may manufacture and dispose of the product themselves. It is not uncommon even for very small ryots who have not sufficient leaf for a vat filling to combine and divide the produce according to the proportion of leaf brought to the vat. The area sown is in general not more in the neighbourhood of a village than the vats there can deal with in the ordinary season, but in South Arcot it is a general practice if the plant cannot be dealt with at the proper time, to cut it and strip and dry the leaves and manufacture from these dried leaves when the vats are free.

A boiling process seen in the Gōdāvari district and the process of manufacture from dried leaves will be dealt with separately.

Methods of Agriculture in Madras.—I am indebted to officers of the Agricultural Department for details of the method of Agriculture followed on indigo lands. Indigo is in general sown as a dry crop but in some localities it is sown on garden and even in wet lands, the ryot knowing perfectly well that although the plant grows much more luxuriantly under the latter conditions the dye content of the leaf is not so high as it is when grown on "dry land."

Land intended for indigo is generally manured either by penning sheep or goats on it or by means of farm yard manure to the extent of some ten carts per acre, although sometimes even double this amount may be given. In dry lands it is often sown mixed with other crops (ragi, mustard, gram, gingelly) the land having been fairly deeply ploughed and the irrigation for the main crop assisting in giving the plants a good start. After the removal of the main crop the land is hoed and the surface is broken up around the stubble after each cutting.

The general period for sowing is in December-January but in dry lands in the Northern districts it may be sown in June-July. The first cutting is taken in about three months, followed at intervals of about two months by second and third cuttings. Sometimes the third crop is left to bloom for seed, but in the Nandyal division the seed is taken from the second crop and the dye made from the third (ratoon) crop, whilst in Gōdāvari the seed is taken from the first crop and the second cutting is taken for dye manufacture. It is a generally accepted fact here that heavier cuttings are obtained from the second crop, the first and the third being about equal to each other, but smaller than the second.

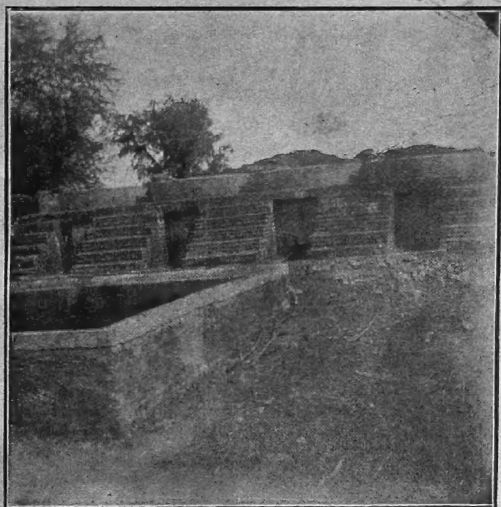
The ryots know that the yield of dye is higher from the plants cut just before blossoming, but vat space is not always sufficient to deal with the plant at the right time so that much plant of poor dye content often finds its way into the vats.

Throughout the Presidency only one variety of plant (*Indigofera Sumatrana*) is cultivated; it is hardy and well suited to the conditions and the preliminary trials of the Agricultural Department to grow the Java-Natal variety have not so far been really successful. The treatment of the seed with strong sulphuric acid which is necessary with this latter variety to ensure germination is not an operation which will appeal to the ryots and when it has been attempted the germination results probably owing to faulty treatment were anything but good, and were not of a nature to impress the ryot with the superiority of the Natal plant over the one the growing of which he is accustomed to and understands.

Seed.—The seed which throughout the Presidency is looked upon as the best is that obtained from the Nandyal division of the Kurnool district. Second comes that from the Lankas of the Gōdāvari followed by Cawnpore seed and Locals. Cawnpore seed is very mixed and that which was obtained this last year gave very poor results, but the demand for Nandyal seed was responsible for a great deal of adulteration being practised there, and the ryots report that not only was a large amount of old seed found mixed in with what purported to be fresh seed but that consignments of seed were despatched from other districts to Nandyal to be disposed of from there as pure “Nandyal.”

Manufacture.—The extraction of indigo from the plant is carried out in vats of brick coated with cement, and generally rectangular in shape, but in Nellore and adjacent districts (as also in Gōdāvari where the manufacture is controlled by Nellore dealers) the steeping vats are cylindrical. The usual capacity of the rectangular vat in this Presidency is about 500 to 600 cubic feet ($15' \times 12' \times 3\frac{1}{2}'$) whereas the cylindrical Nellore vat has a capacity of about 150 cubic feet but they are generally arranged in batteries of three to each beating vat. The steeping vats are built at a higher level than the beaters, so that the steeping liquor flows from the former into the latter by gravitation.

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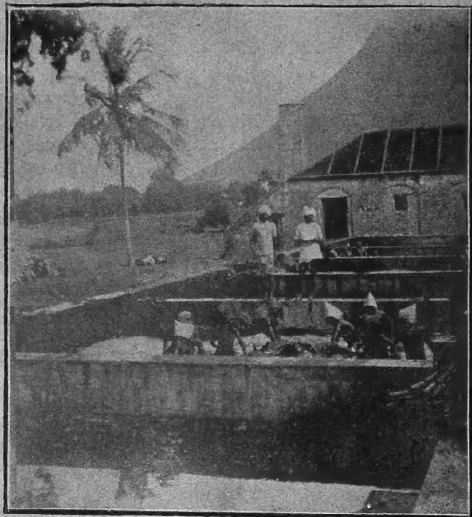


CIRCULAR VATS AS SEEN FROM BEATER. NELLORE.

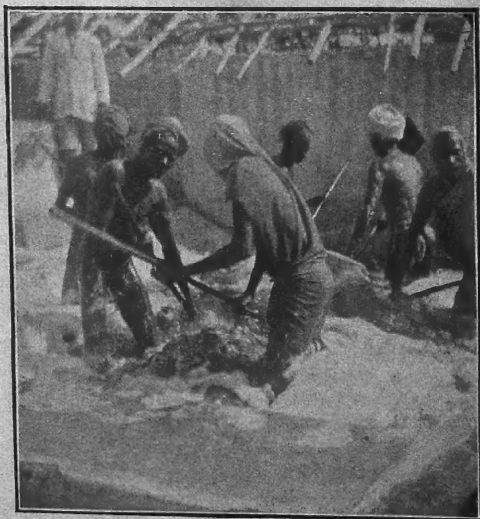


CIRCULAR VATS SHOWING STONES BY WHICH INDIGO
PLANT IS KEPT SUBMERGED. NELLORE.

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MAD.



BEATING VATS, VIZAGAPATAM.



BEATING, SOUTH ARCOT.

The plant is held down in the cylindrical steeping vats by means of large stones but in the rectangular vats flat iron bars are fixed upright at opposite sides (two pairs to each vat) and baulks of timber with slits at the ends fit over these bars and are held down by a stout iron pin.

The water employed in Madras is almost without exception well water, and the wells being in constant use for manufacture and irrigation there is not the liability of variation in quality which is a factor to be reckoned with in cases where the supply is from rivers or tanks. I saw only one vat in Guntūr working with water supplied from a tank and in Vizagapatam where the factories are near the river, water is not drawn direct from the river but from wells sunk near the banks.

Filling.—When ready, the plant is cut about 4 inches from the ground, tied into bundles and transported by carts or head load to the vat where it is stacked (as far as possible) in the shade. Cutting is carried out in the early morning and the filling of the vats may commence about 10 a.m. or be delayed until early afternoon. The filling is done by opening out the bundles and placing a layer (the shoots lying all in one direction) upon the floor of the vat. Each succeeding layer is placed in the alternate direction until the vat is sufficiently full when light bamboo sticks or mats are placed upon it, poles which reach across the vat are laid upon these about 3 feet apart and the whole contents of the vats are then compressed by two heavy baulks of timber which are levered down and held in position by pins passing through holes in the stanchions fixed in the walls of the vat. Water is then run in until it stands just above the level of the plant.

Steeping.—In some 3 to 4 hours evidences of fermenting action are seen and this goes on increasing until the surface of the water is covered with froth formed by the bubbles of escaping gas, and when this froth commences to subside it is taken as a guide that the fermentation is ended and the steeping liquor is ready for running off. This may be in 14 to 16 hours from the time of filling, but the vat is usually let off for beating at daylight the following morning. The steeping vat is then cleaned and prepared for filling with fresh leaf and only then is the beating or aeration of the steeping liquor proceeded with.

The officers of the Agricultural Department have pointed out, by leaflets and by word of mouth, that delays are not conducive to the production of high quality indigo, that a steeping of 12 hours under normal conditions is to be preferred and that all delay in proceeding with the beating should be avoided as leading to destruction of dye. From what I gathered it appears to me that the manufacturer realises the soundness of the advice, but to carry out the recommendations would necessitate the employment of extra labour and that he is not prepared to do. Working as at present the whole of the operations of the manufacture can be carried through by one set of men whereas by setting extra men on for single operations, there would not be a day's work for all and still a full day's wages would require to be paid. It is usual for the labour to be paid at so much per vat manufactured, and this includes filling, emptying, beating, boiling, draining and pressing.

Beating and boiling.—Indigo blue is produced from the steeping liquor by aeration but there are slight variations in different localities in the way in which it is carried out. In South Arcot and around Madras, flat circular pieces of wood are tied firmly to the end of bamboo sticks about 5 feet long to form paddles and standing in the vat in a rough circle

the beaters dash the surface liquor against the walls of the vat or facing towards the centre get a "swing" on the water so that the waves meet in the centre and the spray dashes up above their heads. In Guntūr and Kistna the beaters gradually move round the vat dragging the face of the paddle through the water with semicircular sweeps whereby they raise a big feather, whilst in Vizagapatam district the water is dashed against the vat sides and into the centre by sticks to which are fastened short cross-pieces of wood which are vigorously plunged almost horizontally along the surface of the liquid.

Under the influence of the aeration, the yellowish green fluorescing liquid rapidly changes in colour to a dull green. A thick foam is produced and beating is continued until the liquid becomes dark in colour, and a little liquor being taken up on a plate, the indigo is seen to be well granulated and separating well from the water. A little gingelly oil is now sprayed over the surface to kill the foam, any scum which remains is removed from the surface and the liquor is left to settle. A vat takes from 2 to 2½ hours to beat and if all goes well and the indigo separation is good the topmost plug may be opened in about 3 hours and the surface liquor drained away. To assist settling it is usual in the South of Madras to add a few buckets of clear lime water to the beaten liquor just before the men leave the vat, but elsewhere the general practice is to add an infusion of the bark of the Jambolana tree (*Eugenia Jambolana*).

The plugs in the wall of the beating vat are successively opened until all the clear liquor is drained away or indigo sludge begins to flow. The thin sludge is then transferred by means of buckets to the boiling pan (a conical iron or copper pan set in an earthen fire place) and there boiled over an open fire.

Draining and pressing.—After boiling, the indigo sludge is bucketted on to the draining-table—a thick cotton cloth supported upon sticks in a rectangular trough. Until the pores of the cloth are closed the liquor which filters through is blue in colour and is returned to the table until the filtrate is clear. When the boiler has been emptied and no more liquid will drain from the table, the filtering cloth is lifted at the edges and the indigo paste scraped towards the centre, scooped into buckets and taken to the Press.

The Press box is a wooden frame, made of thick well seasoned planks. It has to withstand considerable pressure so the ends of the side planks are bolted together by iron bars threaded at the ends and fitted with nuts. These side planks are perforated with numerous holes and rest upon a board similarly perforated, thus forming a stout box. A cloth being evenly laid in this, the indigo paste from the draining table is transferred to it until the frame is full when the ends of the cloth are laid evenly over the surface and a board which will pass inside the frame is laid on the top; the Press itself consists of a strong frame upon which the Press box rests with two upright, threaded iron stanchions passing through a heavy wooden beam. Blocks of wood being placed between this frame and the cover of the Press box nuts working on the stanchions are slowly and evenly turned and the contents of the box are compressed, the water remaining in the paste escaping through the perforations. The pressure is gradually increased until no more liquid can be expressed when, after standing, the Press is opened up and the slab of moist indigo is transferred to the cutting

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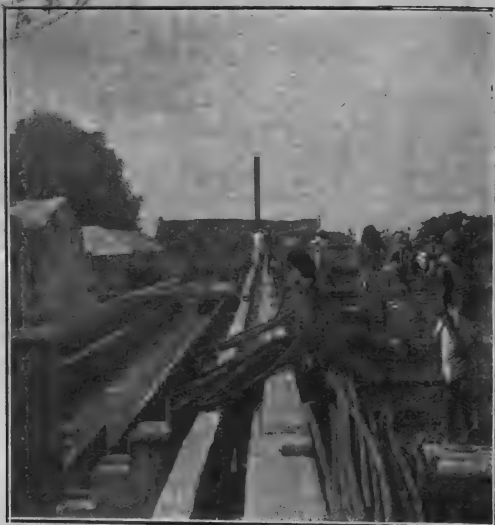


BEATING VATS. CUDDAPAH.



BEATING VAT, BOILING PAN, PRESS AND DRAINING
TABLE SHED. MADRAS.

15 NOV 1933



GENERAL VIEW OF FACTORY SHOWING STEEPING VATS,
WATER CHANNELS, BEATING RANGES, ETC. BEHAR.



FILLING THE VATS. BEHAR.

table where it is cut by a wire into cubes which are transferred to a drying room and there slowly dried ; when dry they form the indigo cakes of commerce.

SOME REMARKS UPON THE MANUFACTURE IN MADRAS AND BEHAR.

The above is a short description giving the essentials of the manufacturing process as carried out in Madras. It appears to be identical with the process carried out in all indigo districts in India up to the latter end of the last century, when in Behar the size of the vats began to be increased and steam power and machinery was introduced for beating and boiling. The number of vats to one estate and the scale upon which the operations are carried out give the impression of a real factory and the controlling heads are trained business men open to suggestions for improvement. These have not been lacking in the past and the suggestions from other managers, and especially from Mr. Rawson who made an extensive study of the conditions of manufacture, have been taken up and tried and wherever found efficacious have been adopted.

A single factory in Behar may easily have 5 to 7,000 acres under indigo and to deal with the produce from this area in the short manufacturing seasons a complete organization of labour and an installation of a large number of vats is required. As I have pointed out the vats in Madras are much smaller and are scattered about singly or in pairs near the villages, and about 30 acres is the maximum area the produce of which can be dealt with by one vat in a month, and although the average manufacturer in Madras knows a great deal about the practical side of the work, his knowledge is traditional and empirical and not based upon the results of recent experiment and research as in Behar.

The records in Behar factories show the area sown, the yield of plant, the amounts filled daily into the vats, the daily yield of indigo, the quality of each day's production, everything in fact which is necessary for effective control, whereas in Madras in general there are no records kept whatever and the statements made to me as to yield of plant per acre, the amount of plant loaded into vats, and the yield of indigo varied so widely that no reliance could be placed upon them.

As an average I would say that with a good crop a first cutting yields about 9 to 10,000 lb. of plant per acre and the second cutting 10 to 12,000 lb. whilst the figures given to me indicate that from 25 to 30 lb. of indigo are obtainable from 5,000 lb. of leaf. These figures are much higher than those for Behar even allowing for increased efficiency which may result from the use of smaller steeping vats and for the lower quality of indigo produced and I can place no reliance upon them. The Saidapet Farm records show that the crop from one acre there was 12,000 lb. of plant and the dye^{yield} was given as 50 lb. To obtain accurate information upon this point I feel that it would be necessary to be present during the operations and weigh not only the plant from a given area but also the finished indigo.

The high quality of Behar indigo in general is due to the care and control exercised at every stage of the manufacture. The plant is cut and carefully loaded so that it is not contaminated with earth, it is weighed as it enters the factory, and is loaded immediately into the

vats and watered. Experience has shown that if the steeping water is too cold (below 90° F.) the extraction takes too long and the produce suffers in quality, so that it is usual there to have steam pipes from the boiler into the water reservoir or supply channel and the water is heated up to about 94° F. before it enters the vat. The temperature during the steeping is noted at intervals by means of a thermometer, and without reference to the appearance of the fermentation, but solely by the average temperature, the time of steeping is regulated and the liquor is let off usually in 9 to 11 hours. Beating starts whilst the liquor is still being run off from the steeping into the beating vat so that all loss of indigo, which may be very appreciable if the liquor stands at this stage is avoided and if the factory routine is such that the vats are let off at night the beating is carried out by artificial light so great is the stress laid upon this point. The beating finished, the liquor is left at rest, but running off is not delayed until the sludge has settled completely, for in place of a series of holes at different heights as used to be the case a single hole is provided at the base of the vat wall; in this is fixed a pipe and within this a pipe of a smaller diameter with a flanged end and to which is fixed a flat funnel the opening of which can be placed at any level in the vat. Immediately there are a few inches of clear liquor, therefore, the top of the funnel is brought just below the surface of the liquid and the refuse water is run away whilst the indigo goes on settling and, as may be required the funnel is gradually lowered until the indigo is completely settled and all clear water is run off. The indigo sludge is then without delay washed into the collecting sump, pumped through a strainer into the boiling pans and there boiled with acid (by means of steam), settled, the top liquor run off, boiled again with water and run on to the draining tables. •

Throughout the process the fact is acted upon that once the liquor is drawn off from the leaf bacterial action cannot result in the production of indigo but only in its destruction, so no delay is permitted in getting the sludge into the boiler where all bacterial action is stopped and practically within twenty-four hours of the plant being cut the extracted indigo has had its first boil.

The manufacturing ryot in Madras cannot be expected to have the same knowledge as the Behar planter and his manufacturing process is controlled not so much by his knowledge of what is required for the production of indigo of good quality as by questions of labour, its cost and convenience. He knows that once the indigo has flowered the dye content of the leaf diminishes, but good plant and that which has blossomed find their way indiscriminately into the vat. Leaf caked with mud from the fields also goes in and usually little care is taken (when as is usually the case the leaves are stacked beside the vat before filling) to see that no further mud or dirt is taken up.

Experienced ryots, I find, know that the indigo contents of the leaf diminish when there is delay in filling into the steeping vat, but if the operations connected with the previous day's manufacture are not completed, no extra labour is put on but the leaves are left to lie until the men are ready; also when the purchase of the crop has not been made on the ground but takes place at the vat side upon the basis of the amount of plant delivered, much delay is caused by the lengthy chaffering which goes on until a rate is agreed upon and the delay does not improve the plant. As previously mentioned the manufacture is contracted for at a fixed rate per vat the same gang of men carrying out



BEATING WHEEL IN ACTION, BEHAR.

all the operations. The time of steeping is not controlled by seeing that conditions for fermentation are of the best ; water is taken direct from the well and of course the temperature of well water is seldom above 80 to 84° F. even in very hot weather so that it takes some time for fermentation in the vat to become brisk. The time of steeping is therefore much longer than in Behar and as it is customary for labourers here to work only in the day time, running off and beating cannot be arranged for at night. Even in Vizagapatam where the supervision approximates to that in Behar, the labourers could only be brought to alter their habits with difficulty and during my tour there I had an example of the extreme suspicion with which they looked upon any change, even the minutest, and experienced the difficulty in getting any alteration made even in the way of experiment. In the villages the time of steeping is seldom less than eighteen hours and is often as much as twenty-four hours ; add to this the delay in beating the steeped liquor and one can realize how easily the decrease in the quality of indigo can be accounted for. A still more serious delay however takes place very often before boiling for—if the sludge obtained is not sufficient to fill the pan it is kept unboiled until the product from the succeeding steep is ready and only then is boiling proceeded with. It is not at all uncommon for three or four days to elapse between the cutting of the plant and the boiling of the indigo paste and throughout this period influences are at work which are destroying indigo.

ADULTERATION.

These delays will account perhaps for the poor average quality of the indigo from some districts like Guntūr where it is not usual for the product to be wilfully adulterated, and no care with the object of obtaining high grade indigo can be expected in those other districts (South Arcot and Cuddapah) where the adulteration by adding fine clay mud to the paste in the boiling pan is, with many manufacturers, a regular practice. Where a deposit of extremely finely divided clay is found it may become a recognised commodity and bought for the specific purpose of indigo adulteration. Thus a “blue” mud (in reality dark grey in colour) is found in the Pulivaga near Rajampet in the Cuddapah district and is largely used, whilst near Cuddapah itself and Konnamangalam near Nellatur, South Arcot, other muds are found which are used for the same purpose. There seems to be no shame attached to the use of these muds, the question being considered merely from the point of view of the price which could be obtained. As one ryot pointed out, the highest price he could get for his best indigo was Rs. 80 per maund ; by mixing one maund of clay with 3 maunds of this indigo he obtained Rs. 70 per maund so that he made an extra profit of Rs. 40 almost for every 3 maunds and appeared quite unimpressed by the consideration that when the demand decreased, as it then showed signs of doing, such adulterated indigo would not find purchasers ; his view was that if it would not sell he could plant other crops which would pay him just as well.

In general it may be stated that it was the high prices ruling for indigo in 1915 which caused the large increase in adulteration and the cultivation will only be continued so long as the crop yields a better return than any other which can be laid down. The ryot is an individualist, without sentiment where his living is concerned and if merchants will buy adulterated indigo, he will put in just as much mud as

will pay him. Of course mud cannot be employed without the appearance of the indigo suffering, so that it is not an uncommon practice for the fruits of the prickly pear to be bruised and the juice, which has a bright purple colour, added to the mixture of mud and indigo to enhance the brightness of the violet streak which is seen when indigo is scratched. The highest refinement in adulteration I think, was reached in Cuddapah district where I found Magenta, a bright coal-tar colour which is absorbed by siliceous matter, was used to colour the mud and give it a colour which is very similar to the coppery streak of indigo.

COST OF CULTIVATION AND RETURN.

In conversation with ryots and manufacturers I tried to obtain information regarding the cost of cultivation and the return, and also of the lowest prices for indigo at which the industry could be made to pay. Needless to say the statements made were so contradictory that little information of any value could be gleaned. The cost of cultivation for dry land seems to be about Rs. 15 per acre and the yield of leaf therefrom valued at Rs. 30 to 45 per cutting. The cost of manufacture is from Rs. 10 to 12 per vat and the yield of dry indigo may be placed at about one Madras maund of 25 lb. per acre per cutting. With indigo at Rs. 40 per maund, the return from seed at about Rs. 18 and the value of "seet" or refuse plant from the steeping plant at Rs. 6 the return works out at Rs. 35 to 40 per acre. The price of indigo at Rs. 40 per Madras maund in the first instance seems to be about the lowest at which the ordinary ryot here would continue to grow indigo and in general it appears to be the price obtainable for the dye which will be the deciding factor, the value of the crop to the land in rotation with others not apparently being appreciated.

Appreciation of Seet as a manure.—Some ryots recognise the value of "seet" as a manure and especially is this the case in the neighbourhood of garden lands where it may be sold at Rs. 10 per cart load. The value of indigo as green manure is also recognised but the point did not appear to be appreciated that if indigo is grown, it is far superior as a manure after the dye has been extracted than it is in the green state. In dealing with a reference from the Director of Agriculture regarding Baron Schrottky's claims I wrote in 1913 "If the indigo plant is worth growing for manurial purposes with the dye stuff as a bye product the outlook is good. If however the dye is to be a main factor, I am afraid the competition will prove to be too great and the sale price in the end be found to be too low to yield the expected return." Rawson in his report to the Indigo Planters Association makes the statement that at prices ruling at the time the value of the "seet" as a manure was practically equal to that of the indigo obtained and stated "the high value of seet as a manure has an important bearing on the position of the indigo industry. Whatever may be the price of indigo as a dye, it should, in my opinion, pay to continue to cultivate the plant in conjunction with other crops, provided the seet is judiciously applied. The soils of Behar and, in fact, of India, generally, are deficient in Nitrogen and in order to grow such crops as sugar, tobacco, cereals, etc., successfully nitrogenous manures must be employed: and for these purposes seet is eminently suitable."

The Behar cultivator also appears to appreciate the value of seet and seet water as a manure more than the cultivator here and a most

successful planter informed me that he was prepared to grow indigo whatever the value of the dye, as he found that in rotation with indigo he obtained a return from country crops which paid him well, thus confirming the opinion expressed by Rawson.

MARKETING.

In Behar and Bengal the indigo having been manufactured and dried is usually forwarded to agents in Calcutta who forward it to England for sale. It is only the produce of the Vizagapatam district I imagine which is forwarded direct from the manufacturer in this Presidency. The usual practice is for local merchants to purchase from the ryots, to grade the indigo into various qualities and dispose of it to larger merchants or shippers in centres like Prodattur (Cuddapah) and Madras. The grading of the indigo and the price offered is generally determined with reference to the specific gravity of the cakes, colour, nature of fracture, porosity and the appearance when scratched with the finger-nail.

Valuation of indigo.—The tests applied give some indication to an experienced man regarding the quality of the manufacture and the behaviour to grinding, but leave much to be desired as a means of determining the colour content, which after all is the main thing. To test the accuracy of the merchants' valuation I obtained from the largest dealer in Prodattur (which is the biggest indigo dealing centre in the Presidency) samples of different grades with prices (referred to a sample of Gundalur indigo which is looked upon as one of the best qualities in the Presidency) and analysed these for real indigotin content.

Source of sample	Price.	Percentage of indigotin.	Price per unit of indigotin	Value of indigotin compared with Gundalur at Rs 90
	RS.			RS
1. Gundalur	90	63	91	...
2. Payakal	80	62.6	81	89½
3. Nandyal	80	55.8	92	80
4. Vontimetta	80	57.8	88	82½
5. Kurnool	80	54.4	94	77½
6. Tadpatri	70	60	75	85½
7. Cuddapah	60	50.5	76	72
8. Prodattur, first lowest quality ...	55	49.4	71	70½
9. Prodattur, second lowest quality ..	50	50.7	63	72½
10. Guntur, lowest quality ..	45	47.2	61	67½

Stated in this way it appears that whatever the ryot may assert in justification of adulteration giving him increased profit, competent merchants pay proportionately less per unit of indigo in low quality grades which is what could be expected seeing that the ultimate purchaser (the dyer) is at greater relative expense in preparing such qualities for his purpose. The analyses of Nos. 2, 3, 4, 5 and 6 show further that the physical tests relied upon by the merchants do not grade the indigo in proportion to the real dye content and it appears to

me they are largely guided in the valuation by their knowledge of the district from which the indigo comes, for in appearance and general characteristics there was hardly any difference between the Tadpatri sample (6) and the preceding ones. In a rough way however the dealer is able to grade his indigos by the tests he applies even though he is not able accurately to grade those of approximately the same quality.

From a consideration of the scale upon which ryots manufacture here and their general indifference to "quality" I do not think they would take advantage of any facilities offered them for having analyses of their indigo made. With merchants who pack for shipment however the case is different, analyses would be useful to them but to be of any value such analyses would require to be made upon samples drawn in the most careful manner so that each sample properly represented the case to which it referred. Such analyses if properly carried out would be a guide to the shipper, but it must not be overlooked that the sale value will be decided by the results of analyses of the sample drawn upon arrival at the port of destination and much will depend upon the competency and experience of the analyst to whom the sample is forwarded there.*

CONCLUSION.

With regard to the growing and manufacturing of indigo all the recent work of investigation and improvement has been carried out in Bengal and Behar and with reference to the conditions there. The report of Mr. Rawson for the Behar Planters' Association in 1904 constitutes a complete record of the conditions at the time, and many practical suggestions are made in it. Under subsidy from the Government of Bengal research work was continued at Dalsingrai under Mr. W. P. Bioxam and at Sirsia under Mr. C. Bergtheil until it was transferred to Pusa to the Imperial Agricultural Research Institute.

Rawson dealt with matters like the indigo content of different varieties of plant, composition of soils, manures and their effects, methods of steeping and beating, addition of chemicals, etc., and the work at Sirsia followed similar lines.

With

- (1) care in the selection of land and seed,
- (2) thorough cultivation and application of phosphatic and nitrogenous manure,
- (3) avoidance of delay between cutting and steeping,
- (4) proper loading of the vats,
- (5) attention to the temperature of the steeping water that it should not be below 90° F.,
- (6) restriction of the time of steeping according to a temperature scale,
- (7) use of fresh water free from organic impurity,
- (8) use of mechanical aids to reduce the time of beating,
- (9) use of acid in boiling the indigo, and
- (10) the avoidance of all delays between the operations from cutting to boiling, it appeared that improvements in obtaining the

* Whilst this Bulletin was in the Press, a communication was received from England drawing attention to wide variations in dye content of indigo cakes contained in one and the same case shipped from Madras.

highest yield and quality of product had reached their limit and Rawson's words "any further aid (from a technical point of view) to improve the position of the indigo industry can only come, in my opinion, from improvement of the plant by natural selection or by the introduction of some other species (such as Natal plant) capable of yielding a greater amount of colouring matter" seemed true.

The Sumatrana variety of plant is still largely cultivated, but an increasing area has been coming under the Java-Natal plant and increased yields were being obtained but the latter variety has shown itself in Behar peculiarly liable to "psylla" and "wilt" disease. Mr. Davis, the Imperial Indigo Chemist, looks upon the latter as caused by phosphate starvation and with regard to the manufacture he considers (from the evidence he has gathered at the factories) that the existing methods are very inefficient and that were the working carried out under efficient chemical and bacteriological control, the yields in many cases could be increased by as much as 100 per cent. He lays stress especially upon the importance of the bacteriological control and from the investigations and results of Mr. C. W. Hutchinson, Imperial Bacteriologist, Pusa, who is taking a great interest in the work, it seems certain that the establishment in the vats of a suitable bacterial flora would enormously improve the yield and the average of regularity of the produce. Results already obtained show clearly that the efficiency of the prevalent process of extraction depends entirely on the nature of the bacteria present in the steeping vat and that according as these are of a favourable or unfavourable type, very different yields of indigo are obtained.

In different districts, in different waters and on different days, variation in the type of the bacteria predominating may occur and account for the variations in yield and quality which are noticed. The well-known fact that in the early days of a season's manufacture, yield and quality are low but progressively improve, certainly points to the influence which a perfect bacterial growth may exercise and if all inimical bacteria could be eliminated and only such as are non-destructive of indigo or indigo-yielding material established, both yield and quality would show an enormous improvement upon the present average.

One point which may account for the generally reported high yields in Madras as compared with Behar is the much smaller capacity of the steeping vats here. In the large vats in Behar (2,000 c. ft.) the ratios of wall space area to capacity is only about $\frac{2}{3}$ of that in the small rectangular Madras vat of about 500 c. ft. Walls, floor, and permanent fixtures in the steeping vat provide lodgment areas for bacteria and experiments in Behar indicate that smaller vats and trellis work or bamboo frames kept regularly in them tend to induce a more rapid and complete extraction of the plant. The more rapid and complete the extraction of the plant, the higher the yield and quality of the product so that it is important to induce conditions suitable for the rapid growth of bacterial colonies and from the start of the manufacturing season to ensure that suitable bacteria are in the ascendancy. Such conditions may account for the fact that the quality of indigo produced in certain districts of Madras is much lower (even though there is no adulteration practised) than in others and there is probably no other reason than that the water-supply contains different types of bacteria;

less efficacious in one case than in the other, for as regards the details of manufacture there is no noticeable difference.

This line of investigation is, I understand, being energetically followed at Pusa and the results and recommendations may be awaited with interest.

Mr. Davis has also drawn attention to the serious losses which may result from bad settling of the indigo separated in the beating vat and draws attention to the efficacy of the addition of a solution of Dhak Gum (from the *Butea Frondosa* or Bastard-teak) in promoting a thorough deposition. In Madras a decoction of the bark of the Jambolana tree (*Eugenia Jambolana*) is generally added to the vat, and whether it be from the use of this or to the fact that well water (free from the low forms of life prevalent in stagnant or tank water) is used, the settling so far as I have seen here is good and there does not appear to be the same tendency to "green" vats as in Behar. I find also that there would be great objection to the employment of Dhak Gum here, as its price is high owing to the demand for it for medicinal purposes.

Marketing.—As already pointed out, the Indigo Committee in London and the Behar Planters' Association working in conjunction have taken steps to test the possibility of marketing indigo in various forms. Where almost direct contact between consumer and manufacturer can be thus established and the consumers' requirements met without delay, there is every prospect of a business being established. It may not be out of place then to consider in this connection the position in Madras, and one is immediately struck by the difference between this province and Behar. In the latter province we have large factories under the control of men who have associations with the outside world and are members of an association which can speak for them as for one man. Arrangements may be made therefore to make contracts and to bring their produce on to the market in the quality and form contracted for. Outside of Vizagapatam no such condition exists in this Presidency; compared with the Behar factories ours is a widespread village industry, the manufacturer disposing of his produce to merchants who collect for shipment. Bulk quantities of indigo are in the hands of the larger merchants and shippers and from a commercial point of view these are more in a position comparable with the factory owners in Behar than are our manufacturing ryots, except that they deal with the product in cake form as it comes onto the market whereas the large factories can presumably supply cake, paste, or powder at demand without incurring extra expense for grinding or other treatment, but may indeed save expense by shipping the product at some desirable intermediate stage of the manufacture.

From a commercial point of view this consideration is of extreme importance; for the minutes of the Indigo Committee show clearly that in the competition between the natural and synthetic product the price at which a suitable product can be delivered to the consumer will be the main deciding factor. Cake indigo is a form in which the common physical tests to obtain an approximate valuation can be applied and this form may find favour among backward peoples, but since indigo can only be used in dyeing in a very finely ground condition the avoidance of the expense of grinding (which is a tedious and expensive operation) is a weighty consideration and I am confident that both manufacturer and consumer in up to date dyeing centres, will prefer if

possible to deal with standardized products of guaranteed indigotin content as shown by chemical analysis, and in such cases the nearer the form of the indigo to that which causes the consumer the least trouble and expense in application, the greater the favour with which it will be received. Unlike the synthetic product, the natural dye can never be economically placed upon the market in the "reduced" state ready for a direct addition to the dye vat; since in the paste form (as it is taken from the draining table) natural indigo is in the best possible state preparatory to reduction, the pressing and conversion into cakes by drying are stages which have later on to be reversed by the dyer and the grinding which this necessitates entails a certain amount of loss and expense.

With freights at the present high rates, it would not pay to ship paste owing to the high percentage of water it must of necessity contain, but means have been devised which appear to keep the paste in good condition during transit and at normal freight rates indigo in paste form would generally in my opinion be preferred to cakes.

What is the position then in Madras as compared with Behar, with regard to supplying any demand of this sort? It must be admitted that from the size of the factories there, the scale of their daily production, and the capacity of their managers, conditions to meet the demand could be more readily assured than in Madras where the individual installations are so small that a week's production almost (even assuming that it were of regular quality) would only make one shipping case. The possibility of getting manufacturers to deliver paste to a Central factory for working up and standardizing was discussed at the Conference at Delhi in 1915 and if some such co-operative scheme could be established in the main indigo centres here, we should be more in a position to meet possible demands from indigo consumers. It would no doubt be difficult to get vat owners to combine in this way, but the idea of Central Factories which with me was purely a suggestion has, I find, been a fact in Vizagapatam for some years, as Messrs. Ripley & Co. in that district use the old lines of vats for steeping and beating and after a preliminary boil the drained paste is carted to one of the Central Factories where it is finally treated and prepared for market.

An organisation to control the manufacture of a wide area and capable of marketing the product in bulk and of guaranteed quality at intermediate stages of manufacture would be more useful, I think, than one which took the finished product as it leaves the manufacturer's hands at present and brought it back at material expense into the form desired by the dyer. Such an organisation would also be able probably to co-operate with the Indigo Committee in London (as is being done by the Behar Planters' Association) but I cannot imagine the ryots, manufacturing and selling on the present lines doing anything but producing cakes and marketing as at present.

Although low grade indigo will never be in much demand in the European market, there may be use for it in China which appears to have been a large consumer of the synthetic dye. Growing and manufacturing is carried on in China, but the process followed there (as described in an article reprinted in the *Madras Mail* of December 28 1917) is one which indicates a lack of all knowledge of the nature of the plant principles and suitable methods of treatment. To mix the plant extract with lime milk as there given, accounts for the nature of a

product analysed by Mr. Davis at Pusa which showed an indigo content of almost negligible quantity.

With a complete organisation in India, high quality indigo might be supplied to European markets, whilst low grade qualities might be readily taken up in China as being much superior to the indigenous product manufactured there.

SUMMARY.

In the early part of the year the Agricultural department issued a leaflet (No. 4 of 1917) upon "Possible Improvements in the manufacture of Indigo in the Madras Presidency" which contains all the advice which we are at present able to give to the ryots. To give fuller details and confirm or disprove the wide variations in statements regarding yield per acre and produce and fix the best conditions of manufacture as applicable to Madras, we should require to control a planted area and at least a couple of vats for some time that we might make proper observations, or we must await the results of the work now being carried out at Pusa and persuade the ryots here to work upon the lines thus found to be the best.

The future of indigo growing for dye will in this Presidency be enormously affected by the market price and at normal pre-war rates the return is not nearly so great as from some other (especially food) crops; we shall certainly see a great reduction this year in the area planted compared with that of the last two years owing to the slump which at present rules on account of the absence of freight and though the introduction of the Java-Natal species would increase the yield per acre, I do not expect that its cultivation will be widely taken up owing to the necessity of treating the seed with vitriol, or scarifying, to ensure proper germination of the seed and to the fact that so far it has not been proved that for the climate here it is so suitable as the Sumatrana variety. The latter is hardy and seems to thrive well here under normal conditions and its treatment is understood by the ryot; the only complaint I have had is of the difficulty in ensuring a supply of sound seed and one point which might be taken up with advantage is the regulation of the seed supply from the Nandyal division of the Kurnool district. The seed grown there appears generally to be considered the best throughout Madras, and on this account much old seed and seed of inferior quality has been forwarded there from other districts and distributed from there as pure Nandyal.

Adulteration.—Regarding the low average quality of Madras indigo, this appears to be due—

- (1) to inability to control the manufacture,
- (2) to deliberate adulteration with mud in some two or three districts only.

In Vizagapatam, Kalahasti, Nellore, etc., it appears possible to produce indigo well up to the average quality of Behar, but there is no doubt that the produce generally varies widely in quality due to the empirical nature of the observations by which the manufacture can be controlled. This cannot be avoided until we are in a position to lay down definite rules for the ryot for the control of the fermentation in the steeping vat and decide upon the indications which will show that the steeping is sufficient, and I am hopeful that the investigations at Pusa

(when complete) will provide these. At present, however, an indigo prepared with all care by the ryot to the best of his ability may be lower in quality than another which has been deliberately adulterated. Both are marketable and are graded and sold in the first instance entirely on the basis of the appearance and behaviour of the cake. The unscrupulous manufacturer aims at adding just as much foreign matter as will not spoil the appearance of the cake and his attitude appears to be that it pays him. If the market price falls and his dye remains unsold, or only sells at what he considers too low a figure, he is prepared to cease manufacture and put his land under other crops. I am inclined to think however that this class of ryot is under a delusion in assuming that adulteration pays him and that the real facts are that in certain districts it is well known that adulteration is the custom, so merchants protect themselves by basing the prices they offer upon the assumption that adulteration has taken place. European firms have ceased to purchase in some of these districts where adulteration was rife and shipment has been undertaken by small growers who took advances and shipped to London at their own risk ; sometimes they made a profit, but more often a loss and have ceased their activities in this direction. Were the ryots dependent upon the indigo crop, means might be found to persuade them of their mistake but as it is clear that the cultivation in many cases only attracted them on account of abnormal prices, they will return to their normal crops when prices fall again.

APPENDIX A.

MANUFACTURE OF INDIGO BY A BOILING PROCESS IN THE
GODAVARI DISTRICT.

The general method of indigo extraction prevalent in India at the present day is that of steeping the plant in water, whereby a vigorous fermentation is induced and when fermentation commences to subside the steeping water is let off and violently agitated with air until separation of the indigo is complete.

The plant constituent from which the indigo is produced is soluble in water and the rate of extraction increases with rise of temperature, thus at the ordinary temperature the complete diffusion takes some hours, whereas at the boiling temperature it is complete in a few minutes. In the latter case the constituent (Indican) is extracted and may be separated in an unchanged condition, but in the former during the lengthy period required for extraction the fermentative changes which take place affect the indican in such a way that oxidation results in the formation of indigotin—the blue dye stuff. The indican solution obtained by extraction with boiling water does not yield indigotin by simple oxidation, but requires first to be treated with an acid; this treatment results in the decomposition of the indican into its components, one of which is the basis of indigotin and is transformed into this by oxidation.

It has long been known that for the production of indigo from the plant fermentation was not necessary and in an essay on the cultivation and manufacture of indigo by Dr. Shortt published in 1860 and awarded a prize by the Madras Government, a process for extraction by boiling is given in some detail. It is not clear however whether the description is that of a process actually in use or indicates lines upon which such a process should be worked.

After discussing the varieties of plants from which indigo may be extracted Dr. Shortt describes the method of cultivation of the plant common in Madras (*Indigofera Tinctoria*), Avari (Tamil), Neel (Hindustani), Neeli (Telugu) and goes on to mention the ordinary steeping process of extraction as we know it to-day. He calls this the "country" process but in the chapter on "Manufacture" he devotes himself entirely to what he terms the "European" method of manufacture and although I have not found traces of or heard of any installation working in the manner described the instructions are so definite that it appears to me they must be based upon practical observation. He writes:—

"On the arrival of the plants at the factory no time should be lost in stacking them into large boilers filled with water for the purpose of being boiled. The boiling should be continued until the leaf yields its colouring matter to the water; in the meantime, each boiler should have an attendant with a large prong with which the plants should be constantly kept under water, and who should be careful to see that the heat of the fire is reduced the moment ebullition occurs, for if the boiling is carried on longer than necessary, the colouring matter will be destroyed. This requires a great amount of practical knowledge, and no rule can be laid down which alone will be sufficient for the guidance of the inexperienced. By opening the cocks occasionally, and observ-

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POT 'BOILING' PROCESS. GODAVARI.

ing the colour of the decoction (which should be somewhat oily in appearance, and have a reddish colour with a peculiar musty odour), we may judge that the period for discontinuing the boiling has arrived."

"At this stage the liquid should be drawn off into the beating vat and there beaten with oars or peddles."

In the attempt to improve the manufacture of indigo in Bengal attention was also devoted to a boiling process and a patent was actually granted for one which closely followed the method described by Dr. Shortt. Trials were made on a large scale about 1,900 but Rawson in his report to the Behar Indigo Planters' Association considered that although the process was capable of yielding an indigo of high quality the cost of fuel was prohibitive and other considerations caused him to doubt whether the process could ordinarily be made remunerative. He thought however that the uniformity in the high grade product obtained made it a process which deserved the attention of managers of factories in which the quality of the indigo produced was always poor. Investigation and research have now taken another line which has for its object the improvement of the steeping process by characterisation and regulation of the bacterial fermentation and if this results in the improved outturn expected there will be little chance of experiments upon the boiling process being renewed.

That a boiling process has been employed for some time however is seen from the Vizagapatam Manual of 1869 in which it is stated that the country method of indigo extraction was by slowly heating the leaves with water in earthenware chatties over a fire and when the boiling reached a certain point pouring the liquor into another larger pot and churning. The "Pot" manufacture which I found at present in vogue in Vizagapatam district is nothing but a steeping process carried out inefficiently on a very small scale, but in certain villages in the Gōdāvari Delta ryots still manufacture indigo by the process indicated in the Vizagapatam Manual. Watt in his article on Indigo in the Agricultural Ledger (page 62) indicates that this was in reality the general country method of manufacture. He states "Throughout India, wherever European Planters influence has not extended the natives extract their blue dyes by a very similar process to that formerly pursued by the woad manufacturers," (i.e., by the use of warm water and lime) and goes on to mention as an example the practice as followed in Gōdāveri.

As seen by me at Rameswaram village in the Coconada taluk of the Gōdāvari district this process was carried out as follows :—

A fire place of mud some 15 feet long by 3 feet broad by 18 inches high is built in the open, and holes are left in the top in which a double row of earthenware pots, 12 in number, are placed. The pots are of 3 to 4-gallon capacity and the indigo plant being stripped of large stems the leaves and small twigs are pressed into the pot and covered with water. The larger stems, palmyra leaves, and brushwood serve as fuel, the fire beneath the pots being continuously replenished and the smoke escaping by a hole at one end of the range.

The liquid in the pots is not heated to ebullition but the worker in charge of the boiling stands by with a small scoop with which from time to time he lifts some of the liquor and notes its colour and judging from his experience that the extraction is right (the liquor being of a bright amber colour and free from any dull brownish tinge) the pot is removed and emptied into a large earthenware jar of about 80-gallons capacity whilst a freshly filled pot takes its place on the boiling range.

One potful of cold water is used to rinse the leaf in each two pots after boiling the washings being added to the liquor in the large collecting jar. The boiled leaf is removed, the pots refilled at once with leaf and water, and placed ready by the boiling range to fill the range as required. A full range is thus always being heated and the process is practically continuous.

Immediately one of the collecting jars is full the contents are aerated whilst still hot by vigorous plunging with a stout rod, split at the bottom and the ends fastened to a ring of twisted fibre about 6 inches in diameter. At first a vigorous frothing is caused but this rapidly subsides and the beating is complete in about a quarter of an hour. A small quantity of an infusion of the bark of the Jambolana tree (*Eugenia Jambolana*) is then added, a few more strokes of the plunger given, and the contents of the jar left to settle.

Some six inches from the bottom of the jar is a hole in the side closed by a plug; after settling, the plug is removed and the clear liquor, free from indigo, is run off. The jar is slowly tilted to bring the level of the draining hole lower and lower until the deposited indigo particles begin to come away with the liquor. The residual contents of the jar are then strained through a very rough woven cloth to remove leaves and small twigs and the thin indigo sludge is collected, drained on a fine cloth to remove excess of water and sold as a thick paste to merchants, or dried in the form of small balls and sold to local users.

About nine boilings in each pot are obtained per day and the total daily yield is about $\frac{3}{4}$ lb. of indigo; there were some eight men and boys working together and I calculated that they were earning less than 4 annas per day. The indigo I obtained direct from the workers was fairly bright in colour and analysed 43.5 per cent indigotin in the dried state. I had had forwarded to me previously however two samples of what purported to be indigo of this manufacture; but obtained from merchants to whom it had been sold in the paste form; these samples contained only 7 and 8 per cent indigotin respectively, and had been heavily adulterated with red clay and charcoal.

From the large scale experiments conducted by Rawson in Behar there is no doubt that, although the total weight of matter extracted from the plant is smaller in the hot water process than by the usual steeping method the quality of the indigo is uniformly higher. In two trials, indigo testing 75 per cent was obtained with hot water whilst the comparative steeping trials on the same days yielded indigo of 65 and 60 per cent respectively, and in trials in small vats the difference was much greater in favour of the hot water process.

The difficulty in the steeping process lies in the lack of control which can be exercised over the bacterial fermentation; in the hot water process the period of action is so short that the bacteria are not able to multiply to any material extent under the conditions under which the process is carried out, and the resolution of the indican extracted from the leaf must be due entirely to the enzymes present in the plant. Rawson states "When indigo plant is immersed in water at a temperature of 150°-160° F. the colouring principle is quickly extracted and transformed through the agency of enzymes (unorganised ferments) into a form of indoxyl which is converted into indigotin by the action of air. Experiments made on a small scale have shown that the extraction and transformation take place in the course of 20 minutes or half an hour."

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BEATING ('BOILING PROCESS'). GODAVARI.

APPENDIX B.

MANUFACTURE OF INDIGO FROM THE DRY LEAF.

Although the most general and apparently the most economical method of manufacturing indigo from the plant is by the steeping of the whole plant, it is sometimes impossible to deal with the whole of a crop at the proper time in the vats available, and especially in South Arcot the practice of manufacturing from the dried leaf is in vogue.

According to the season of the year and the age of the plant there are variations in the indigo yielding content of the leaves but it is well established that whatever the season this content begins to diminish when the normal course of the plant life is interrupted by cutting. In life the destructive and building up changes balance one another and the general composition remains fairly constant over given periods; with the cutting of the plant the balance is altered and the changes in the plant juices must be constantly altering until the cuttings are dried and withered. In the case of indigo plant the most evident fact is that a progressive loss of indigo yielding material occurs, and if the drying period is sufficiently prolonged, steeping and fermentation will yield no indigo at all. By exposure to rapid drying conditions however the changes appear to be largely prevented by the evaporation of the juices and when quite dry the indigo yielding contents are preserved and can be extracted after long periods of time. The real indigo yield cannot be so high as from the fresh plant but where it is impossible to deal with this, extraction after drying appears to be profitable. No exhaustive investigations have been conducted upon the conditions of drying and the process followed in South Arcot is probably evolved as a result of observation and experience of practical results.

The plant is cut and spread in thin layers so that by exposure to sun and wind the leaves are rapidly dried and are then stripped, collected and stored in bags. For indigo manufacture the dried leaves are steeped in water, the weight of water being about six times that of the leaves but the time of steeping is usually much shorter than in the case of the freshly cut plant. The liquor is strained through cloth upon being drawn off into the beating vat, where it is beaten in the ordinary manner, but it appears usual to add a rather larger quantity of lime water or even milk of lime at the conclusion of the beating to assist the deposition of the granulated indigo. All other operations are identical with those followed in the manufacture from the green plant.

The quality of the indigo manufactured in this way is not equal to that manufactured under the best conditions from green leaf, but the better qualities reach a fairly high average, in general quite equal to that of the adulterated product of the South Arcot district. I was supplied with dried samples of different market qualities and found all to be quite good as regards appearance of the cake, whilst analysis showed the first quality contained 45 per cent indigotin and the lowest about 29 to 30 per cent.

